Environmental impact of ICT and implications for e-waste management in Romania

Impactul TIC asupra mediului şi implicaţiile asupra managementului e-deşeurilor în România

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Abstract

The development of Information and communications technology (ICT), as core of the digital economy, presents contradictory effects on the environment. The paper presents the main perspectives of environmental impact of ICT, especially in relation with waste electrical and electronic equipment (WEEE, e-waste), as they result from the approaches found in literature and the reports of official international and national bodies. The analysis of impact on environment and e-waste is done on two levels: the impact of ICT sectors and the impact of electronic applications (including the electronic commerce).

The article ends with customizing the characteristics of the digital economy in Romania. Particular attention is paid to WEEE generated from the development of the digital economy and the significant challenges which the systems of collection, treatment and disposal must meet the environmental requirements.

Keywords: *information and communications technology (ICT); digital economy; environmental impact; waste electrical and electronic equipment (WEEE, e-waste).*

Rezumat

Dezvoltarea tehnologiei informaţiei şi a comunicaţiilor (TIC), ca element central al economiei digitale, are efecte contradictorii asupra mediului. Lucrarea prezintă principalele aspecte ale impactului dezvoltării TIC asupra mediului şi, în special, asupra deşeurilor de echipamente electrice şi electronice (DEEE, e-deşeuri), aşa cum rezultă din abordările întâlnite în literatura de specialitate şi în raportele oficiale ale unor organisme internaţionale şi naţionale. Analiza impactului asupra mediului şi e-deşeurilor se realizează pe două planuri: impactul sectoarelor TIC şi impactul aplicaţiilor electronice (inclusiv comerţul electronic).

Articolul se încheie cu particularizarea aspectelor caracteristice economiei digitale în România. O atenţie deosebită este acordată deşeurilor de echipamente electrice şi electronice generate de dezvoltarea economiei digitale şi provocărilor semnificative cărora sistemele de colectare, tratare şi eliminare a deşeurilor trebuie să le facă faţă pentru respectarea cerinţelor de mediu.

Cuvinte-cheie: *tehnologia informaţiei şi comunicaţiilor (TIC); economie digitală; impact asupra mediului; deşeuri de echipamente electrice şi electronice (DEEE, e-deşeuri);*

JEL Classification: Q44, Q53

Introduction

Since the 90[s] the economic sector is undergoing a fundamental transformation characterized by developing and disseminating information and communications technology (ICT). Since the emergence of ICT has contributed significantly to increasing productivity in various economical sectors, the sustained performance of several technological revolutions and, most importantly, the whole sector become the engine of economic development (Cohen, DeLong & Zysman, 2000; Litan & Niskanen, 1998; Tapscott, 1996).

The process of transition from predominantly industrial economy to the ICT-based economy was achieved gradually by the exponential growth of mobile communications and the number of Internet users, enhancing the ICT sector contribution to economic growth and job creation, the restructuring of large companies Informational systems, accelerated development of electronic commerce, etc.. So we are faced with economic transformation in the meaning of digitization in the literature there are different perspectives about the size, predisposing factors and implications of this complex process. Regardless of the concepts used to characterize this process, "Economics of Innovation", "network economy", "weightless economy", "knowledge economy", "e-economy" or simply "new economy" (Cohen, DeLong & Zysman, 2000), the term "digital economy" is considered conclusive for the integration of ICT in specific economic activities and processes. Digital economy can be regarded as a new dimension to the old economy, the manufacturing of products, services, lifelong learning and innovation are made possible by modern technology support transmission and processing in the context of market globalization and sustainable development.

The concept of digital economy emerged in the early '90s in the United States, as an effect of the use of personal computers, mobile occurrence, development software technology, the explosive growth of data networks and Internet-based services.

Literature examines the implications of the digital economy development in terms of three essential characteristic, respectively the economic, social and environmental impact. The physical infrastructure for storing, analyzing, processing and transmission of information is a means of generating large quantities of waste electrical and electronic equipment, inadequate management of which has a strong impact on the quality of environmental factors. Digital economy

enables to realize on-line transactions, having a significant impact on economic processes and relations between the different competitors. From a social point of view, the easily sharing of information between persons and organisations develops communication in public space, social initiative and integration of individuals into different groups and organizations. Digital economy definitely marks a new stage of human civilization, changing the conduct of daily activities through the intensive use of IT in all spheres of human existence.

The environmental dimension of the digital economy deserves great attention more than other dimensions, because it is one of the important aspects of sustainable development (Munasinghe, 1996). In addition, history has shown that economic development is always associated with certain environmental consequences. Understanding the possible environmental impact of the digital economy is important because it provides valuable insights to identify and coordinate environmental policy research, strategic objectives and various economic instruments that can be used for prevention and control of externalities. Abundance of subject about environmental impact of the digital economy, both in literature (Hurst, 2001; Jokinen, 1998; Jokinen, Malaska, & Kaivo-oja, 1998; Sui & Rejeski, 2002) and in various reports of international bodies shows ongoing concern of specialists and increase awareness of the significance and implications of these issues.

The environmental impact of the digital economy

Debates and assessments of social and economic impact of digital economy lasted for decades. Although most studies and reports produced not strictly focused on the emerging digital economy, research results are considered valuable for economic and social impact assessment. In the post-Fordism era, the environmental problems specific could not be solved with solutions and market mechanisms. It is shown that "implacable logic" of capitalism lead efforts to solve environmental problems to a halt inevitable (Lipietz, 1992). One of the inevitable results of post-Fordism era was the emergence of local economies in which small businesses and various departments of large companies were able to develop more easily. It was considered that restructuring the economy would help reduce negative environmental impacts. However, the implications of the information society were not explicitly considered in the context of these changes.

In general, environmental effects of the digital economy are a double-edged sword, because they have both positive and negative effects.

The rapid pace of technological change in the field of electronics has made appliances for homes and office equipment both affordable and widely used. The extreme growth rates but also ever increasing obsolescence rates result in large quantities of electrical and electronic equipment being added to the waste stream. A broad range of goods is classified as electrical and electronic equipment, including large and small household appliances; Information and technology (IT)

equipment including computers, computer games and peripherals; cellular telephones and other telecommunication equipment; portable electronic devices, video and audio equipment, including MP3 players and peripherals; and electrical tools. If the electronic waste are recycled and disposed without any controls, there are predictable negative impacts on the environment and human health.

The exponential increase of the mobile communications and of the number of the Internet users, the ITC sector's contribution to the economical growth, the restructuring of the companies and businesses in general in order to benefit from the new technologies, the accelerated development of the electronically commerce represent elements of the digital economy.

Optimists summarize the potential positive impact of the digital economy by using the "3D effect" de-materialization, de-carbonization, and de-mobilization. Their beliefs are based on several arguments. First, production, processing and transfer of information becomes increasingly important higher in all types of economic activity, compared with production of material goods, whose importance is inevitably decreasing, we believe that replacing the "atom" with the "bit" provides globally significant energy savings, materials and supplies. Changing economic structure led to reduction of highly polluting industries such as mining and manufacturing and industrial growth as "clean" such as the IT and services sector, we believe that pollution will be decoupled from economic growth due to reduction material and energy consumption in production processes and supply of goods and products. Are becoming stronger beliefs that technological specialists is able to promote significant reduction of pollution, more efficient use of natural resources and reducing energy consumption by developing "clean technologies".

The so-called "rebound effect" can cause unintended consequences, negating the overall environmental benefits obtained by the 3D effects. Digital economy can stimulate rather than reduce consumption of certain types of goods. The continuous growth of paper consumption worldwide in 1950 so far may be evidence that the substitution effect of the digital economy is not as pronounced as was expected, so the bits can be considered supplements rather than substitutes atoms. On the other hand stimulates the expansion and diversification generation ICT and development of more links between economic sectors and thus more choices for consumers. The most likely consequence is the induction of new passenger and freight flows and creating new demands for free movement of goods and people in physical spaces (Marvin, 1997).

In general it appears that both optimists and pessimists offer partial answers and inconclusive about the potential environmental impact of the digital economy, so any generalization is premature.

We believe that studies to date have produced three major shortcomings: lack of empirical evidence demonstrating that there are adverse effects of digital economy development in economically, environmentally and socially, no methods to quantify the impact, in its various manifestations and lack of regional

perspective on the mechanisms of prevention and control of environmental consequences.

The impact of the digital economy on WEEE can be divided into three categories: the impact of ICT sectors, the impact of electronic applications and the impact of electronic commerce.

The impact of ICT on the environment and WEEE

The ICT sector can be considered as the core digital economy. In this context, many studies debate the environmental impact of ICT.

Berkhout and Hertin (2001) draw a distinction between the different types of environmental effects of ICT and e-commerce (see Table 1).

ICT environmental impact

Table 1

	Positive effects	**Negative effects**
First order effects	Environmental ICT applications	Environmental impact of production and use of ITC (*WEEE*)
Second order effects	Dematerialization (getting more output for less input resources)	Incomplete substitution
Third order effects	Life style changes (green consumerism)	Rebound effect (growth of long distance travel)

Source: adapted from Berkhout and Hertin (2001)

According to Berkhout and Hertin (2001), the production, use and disposal of electronic products has a major direct negative environmental impact.

Understanding of the ICT environmental impact factors becomes easier by studying the impact on two levels: direct impact, materialized in the life cycle of ICT hardware and indirect impacts (the impact of control), resulting from the diversity of existing ICT applications.

Plepys (2002) argues that expert studies should consider both direct and indirect effects of ICT on the environment. Contrary to widely accept that digital economy contribute decisively to generate additional quantities of hazardous waste to the environment, Plepys believes that ICT could help to decouple economic growth from environmental degradation.

An opposite view argue Langrock, Ott and Dworak (2002), who believes that ICT products are far from being "environmentally friendly" due to hazardous substances found in components. The authors examine the life cycle of ICT products in terms of four stages and conclude that both direct and indirect environmental impacts are not sufficiently understood. Therefore Langrock et al. (2002) provides a set of solutions to reduce negative impacts of products and

computer applications, studying the appropriateness needed during their life cycle (see Table 2).

ICT solutions for improving sustainability products

Table 2

Phase in the life cycle	Possible solutions
Purchasing raw materials and materials	Predominant use of recyclable materials, avoiding exploitation of primary resources, use recycled substances possible, avoid hazardous substances.
Production	Reduction of hazardous substances and energy consumption per product (eco-design)
Consumption	Adopting measures to resell waste products, encouraging repair and reuse of products, promoting ICT equipment leasing, developing special waste collection channel of ICT products, post-consumer stage.
Final disposal	Pretreatment components containing toxic substances, prevent untreated waste disposal from ICT products, promote recycling of electronic components, combat illegal exports of waste electrical and electronic equipment

Source: adaptation after Langrock et al. (2002).

Association of environmental issues with the various phases of the life cycle of ICT can be a starting point to research potential solutions and public policy initiatives on prevention and combating negative effects of ICT development on the management of WEEE.

Some direct results, especially those that occur in manufacturing of ICT products, was covered by the first generation of environmental policies. But most aspects of environmental impact of the digital economy and the management of WEEE, both direct and indirect, are unfortunately ignored.

It is customary registration and periodic measurements of emissions of toxic substances in production processes, but avoids carrying out impact studies on the adverse effects of discharges of hazardous substances.

Furthermore, knowing the degree of toxicity of WEEE stored long-term uncontrolled and estimate the impact of hazardous substances contained therein are far from accurate.

Finally, many indirect effects such as increased energy and primary resources are not considered systematically. So there are a bunch of coordinates that form the complete picture of the impact of ICT on the environment generally and the management of WEEE, in particular.

The impact of electronic applications

Indisputable that the emergence of ICT applications has led to new challenges facing the environment. On the production side there were two obvious trends, outsourcing and relocation of manufacturing production units, which have substantially contributed to the dissemination of environmental effects worldwide. Compressing product life cycles and electronic applications as a result of rapid obsolescence led to increasing pressure on the environment, quantified by the explosive growth of WEEE. On the consumer side there have been significant developments in the galloping growth of marketed products and electronic applications, due primarily to facilitate access to information about advertised products. But rising sales of specific ICT products attract WEEE itself and thus generate more pollutants.

Reichling and Otto (2001) argue that in certain circumstances telecommunications and network infrastructure can provide new opportunities for energy efficiency and resource consumption, but they are not inherently more environmentally friendly. Referring to the benefits of organic nature of the digital economy, Romm (1999) claimed that in a digital economy is emitting fewer pollutants as a result of rising global productivity and reducing energy and resource consumption in production processes.

Contrary to the views of Reichling and Otto (2001), Mills (1999) believes that environmental issues is very difficult in the Internet age, because a large amount of electricity needed for production, analysis, processing and circulation of information in the network. Mills' calculations show that 8% of total electricity generated in U.S. are used for Internet operation. In turn Marvin (1997) examines the consequences of developing telecommunications systems on the environment and concludes that telecommunications will not only generate additional need to make trips to various places in the world, will lead the operation within the freedom movement and increased flows passengers.

Development implications of the digital economy must therefore designed and evaluated in both directions, so that brings advantages in certain sectors of economic and social environment and the ecological disadvantages intercessory. Overall, the balance will tilt in favor of the advantages or disadvantages? Note that the certainty of response is extremely difficult to assess.

The development of ICT opened the door for a revolutionary form of trade, the electronic commerce, which became a very important part of the larger sphere of ICT.

Literature offers the most interesting perspectives on the extent that electronic commerce promotes pollution prevention and control.

Gay (2002) carried out extensive comparative studies seeking to identify similarities and differences between e-commerce and traditional commerce. The author falls into five distinct categories of business: bookstore and stationery, groceries and perishable food products, software compact disc, music industry and personal computers. A comparative analysis of trade sizes in all five sectors

considered, Gay concludes that e-commerce is beneficial for reducing energy consumption and contributes significantly to reducing pollutant emissions.

Hurst (2001) identified 13 direct and indirect effects of electronic commerce on the environment. Hurst drew the conclusions from case studies conducted at seven companies specializing in electronics and as a result of centralization approaches from literature. The author explains that the most direct and indirect effects are not known / collected and are therefore difficult to assess. Using the comparison with an iceberg, Hurst indicated that lack environmental impact of electronic commerce (part of the water) was more voluminous than the knowledge of the effects on environmental factors (the part above water).

Using the life cycle analysis (Life Cycle Assesment - LCA) in traditional and "digital" providing communications services, Zurkirch and Reichart (2001) were able to identify the nature and determinants of environmental impact. And issues such as environmental implications of telecommunications services are depindente in far more than the actual context in which these services are provided rather than how to provide services (traditional or digital form). So because of the impact of telecommunications on the environment does not have roots in the development of transport infrastructure, but the complex contextual factors that are developing such services. Generalizing, we can consider that issue environmental impact of the digital economy should not be viewed strictly environmental perspective, but must be balanced with economic and social context in which such phenomena exist and develop.

Digital economy in Romania and the impact on the WEEE

Multiple facets of the digital economy gained lately in Romania. In general there have been major increases in information society indicators and IT equipment marketed (Eurostat, 2010).

Population access to the Internet rose from 21% in 2006 to 31% in 2009, more than 38% of households in Romania owning an Internet connection, either broadband (24%) or other types of connections. 77% of online population accesses the Internet from home and 31% of the work, while 20% of Internet browsing at a terminal located in schools. Very few Romanian interact with public authorities via the Internet, about 5.8% in 2009.

Information Society has taken off in business. If in 2006 only 57% of companies had Internet access in Romania, the share rose to 73% in 2009 (41% via broadband connection), but only 27% being present on the Internet through their websites. Only 61% of large companies have a website. But business is not yet completely familiar with the advantages of Internet connection, as proof that only 4% of companies in Romania make online payments and 3% support bills online. Although, in 2007 only 1.2% of enterprise profit due to the use of electronic commerce (Eurostat, 2010).

Digital economy slowly but surely penetrating socio-economic environment in Romania the population's access to technology and IT equipment is becoming less restricted. In 2006, for example, approximately 30% of the population owned a computer, and in 2008 the percentage rose to 35% (Eurostat, 2010). A similar upward trend, but showed more pronounced among the population access to mobile phone in 2008 reaching a penetration rate of 114%. Despite this only 75% of Romanian having one or more mobile phones.

According to a study conducted by Daedalus Millward Brown (2009) for Romanian Association EcoTic on a sample of 1000 people in cities with over 50.000 inhabitants, the number of Romanian having a telephone at home has decreased by 7,5% during September 2008 - June 2009, but the number of mobile phone has increasing considerable. On entertainment electronics segment, the number of holders of digital radios rose from 51.3 to 58.9%, the percentage of those who have MP3 playback devices increased from 30.5 to 37.9% and number of DVD players owners increased from 63.5 to 67.3%.

Statistics taken from National Institute of Statistics (2008) show that electrical and electronic equipment of the population has increased significantly since 1990 in all categories (Table 3).

Population endowment with electric and electronic equipments (end of year)

- pieces /1000 inhabitants –

Table 3

	1990	**1995**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Audio sets	286.5	306.0	362.6	380.9	432.5	514.6	628.7	686.0	743.8	805.1
TV sets	190.9	224.7	270.8	292.2	327.7	366.3	415.8	454.7	491.4	531.6
Refrigerators and freezers	174.8	196.4	216.2	223.6	243.5	261.9	279.9	307.6	333.7	374.0
Electric washing machines	149.2	147.7	152.7	158.2	169.0	189.0	212.6	235.1	254.2	265.5
Vacuum cleaners	77.2	86.8	100.4	104.7	114.2	133.5	154.7	182.3	204.0	213.7

Source: (INS, 2008)

Generally, the number of electrical and electronic equipment is increasing mainly due to lower their lifetime limitation and repair worn equipment, but also because the mechanisms and economic benefits and administrative challenges.

Certainly in Romania was commercialized in 2007, approximate 217,270 tonnes of electrical and electronic equipment, with 54% more than in 2006 (from the available data from the National Environmental Protection Agency and Eurostat). The largest amount of equipment sold within category 1 - " large household appliances" with a percentage of 45% of the total, followed by category 3 - "IT and telecommunication equipment" with 29% and category 4 - "Consumer equipment", with 17%. Distribution is justified by the Romanian consumer appetite

to modernize and adequately equip the household, after a period in which it was not possible, the specifics of each product and the age of appliances owned general population.

Clear trend of increasing quantities of electronic equipment sold in Romania is confirmed by the European statistics, under which Romania record accelerated annual growth (Huisman et al., 2007), from 8,627 tonnes of IT equipment sold in 2003 to 21,470 tonnes in 2007. This situation was recorded given that only 2.1% of PIB in Romania is targeting the IT sector.

Definitely huge volume of electronics devices marketed translates into pressure on the environment, because at some point become waste electrical equipment and appliances from wear or natural. Huisman et al. (2007) estimate that amount of waste generated by households will continue to grow in the timeframe 2010-2020.

Computers are one of many examples of equipment in households that are subject to increased obsolescence process. Another example is television that once the transition to digital television services and switch-off by the UHF frequency band (scheduled to be complete in Romania, to 01.01.2012) will become inoperable while working perfectly now.

According to the Daedalus Millward Brown study (2009) a large proportion of respondents (but fewer than that recorded in surveys in previous years) hold electronics more than five years.

Customers intending to use electronics in their possession until it fails. The percentages vary between 40% and 58% depending on product mix. For example, 45% of respondents who say they do not have a laptop are going to change until it is no longer functional, while only 7% thinking of an upgrade in less than a year. Is an increase in the number of people who have bought microwave (61,0% - 68,1%), food processor (45,3% - 51,2%), and electric shavers (26,6% - 34,2%).

The Daedalus Millward Brown study (2009) also revealed that over 60% of Romanian property has broken equipment, saying most have a specific purpose, 26% intending to repair and only 6% wanting to discard. The factor that proved to be the most reason to depart from old or faulty electronics and appliances are the buy-back campaigns, where consumers receive a discount on the purchase of new equipment against surrender of the old. Although 90% of survey participants agree that selective waste collection activity is important for the environment, most people do not act in this direction. Romanians appear to be willing to adopt environmental behavior on disposal of electronic equipment only if this does not require great efforts on their part.

In this context the question that will take destination quantities of WEEE arising from electrical and electronic equipments physical and moral wear. So advanced technological shift to digital information society and economy are factors of pressure on management systems for WEEE. Inevitably after such processes continuously generate large amounts of WEEE, the toxicity of substances present in electronic components to be collected, treated and disposed of properly.

In 2007 were collected in Romania 3,286.85 tonnes of WEEE, less than 1 kg / person / year. From total quantity of WEEE collected in 2007, only 8% were treated, the rest being in stocks of private operators registered in the official collection of WEEE (ANPM, 2009). The situation improved in the next two years.

EcoTic, the largest non-profit association in Romania dealing with waste management of IT electronics and appliances, collected and recycled 9,000 tonnes of WEEE (approximately 50% of the amount collected nationally) in 2008 and 10,500 tonnes in 2009. Environ, another important collective organization for WEEE management, collected 3,300.73 tonnes in 2008 and 5,298.22 tonnes in 2009.

Romania is working to collection and recovery of electric and electronic components in the context of the need to align to European and international requirements and standards, but the results obtained are far from satisfactory.

The transition process in the digital economy brings a number of structural changes which Romania has to face. Clearly nationally increased penetration of IT products and such a trend will issue sooner or later appropriate disposal of waste products in the post-consumption. Concerns must be developed in parallel to stimulate giving up using old equipment, some defects that the population owns them. Although in recent years has reduced the percentage of people in household electronics store inoperable, there are cases where people continue to remain in ignorance of alternatives available for disposal under appropriate conditions.

Conclusions

New technologies developed on digital economy allow access, storage, processing and transmitting information in an easy and affordable way. In this context, where the economic processes are conducted through information technology, we can consider the waste is generated in much smaller quantities. Things are not so simples and the assessment of both positive and negative impacts of the digital economy on the WEEE is extremely difficult.

Electronic information can be transformed into new economic and social values, creating great opportunities for developing new products and services. So, information is a key resource of the digital economy, but in order to make functional the information is necessary to develop specific infrastructure.

In the new economy there is a large number of networked computers and other electrical products. Certainly at some point will have to replace them and so will produce additional quantities of waste. Computer peripherals, equipment necessary to operate the networks and others, will become electronic waste when they will be replaced with better performing equipments.

Continuing the logical thread of discussion, it is necessary the preparation and education of citizens in order to be able at any time to use new technologies.

In such a context the question is, if widespread use of ICT's, that generates the advance of digital economy, will ensure growth in terms of environmental protection.

Remains a research theme if the advance of digital economy will reduce the physical consumption, in favor of information and knowledge use.

The shift of gravity center from fixed assets investment in human capital investment contributes at first sight to reduce pressure on the environment. The information society integrates the sustainable development objectives, based on social justice and equal opportunity, freedom, cultural diversity and innovative development. In the same time, digital economy generates an increase quantity of electrical and electronic equipment, which become waste at a level higher than can be collect and treat by the WEEE management system.

Acknowledgments

This work was supported by CNCSIS –UEFISCSU, project number PNII – IDEI 1834/2008.

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